CLAY MINERALS IN RECENT MARINE SEDIMENTS

BY

ROBERT SINCLAIR DIETZ
B.S., University of Illinois, 1937
M.S., University of Illinois, 1939

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN
GEOLOGY IN THE GRADUATE SCHOOL OF
THE UNIVERSITY OF ILLINOIS, 1941

URBANA, ILLINOIS
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ACKNOWLEDGMENTS

Most of the samples used in this investigation are from the collections of the British Museum and were obtained by the *Challenger* and other British vessels. Other samples were collected by various persons and institutions for P. D. Trask's study of the source sediments of petroleum. The writer wishes to express his appreciation to Dr. Trask, who kindly made the samples available. The writer also wishes to express his gratitude for the guidance of R. E. Grim and of F. P. Shepard, and for the assistance and suggestions of K. O. Emery and R. H. Bray. The preparation and the study of the samples were accomplished in Dr. Grim's laboratory at the Illinois State Geological Survey.

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ABSTRACT

I. Introduction

A study was made of the clay fraction of 39 samples from the various oceans of the world. The writer selected samples which he considered representative of the common types of marine sediments such as red clays, pteropod, diatom, radiolarian, and globogerina oozes, and green and blue muds.

II. Methods

After a pretreatment which destroyed organic matter and carbonates, the particles less than 1.0 micron in diameter were separated from the remainder of the samples by settling methods. This fraction was further split by means of a high-speed centrifuge into a coarse clay fraction (1.0 to 0.1 micron) and a fine clay fraction (less than 0.1 micron). The clay mineral composition of these fractions was studied by petrographic and x-ray diffraction methods.

III. Results and Conclusions

The relative coarseness of the clay particles in the sediments from different regions was determined by comparing the amount of material in the coarse clay fraction with the total amount in both the coarse and fine clay fraction. This study showed that, in general, the clay particles of the red clay samples are coarser than those of the green and blue muds which in turn are usually coarser than clays in tidal estuaries, bays, and inland seas. Data adapted from other sources showed that most soil clays and also clays being carried into the sea by the Colorado River have a finer particle size than the marine clays. Consequently, marine clays of at least the blue and green muds of undoubted terrestrial derivation, probably undergo a post-depositional increase in grain size.

The base exchange capacity of two Pacific red clays was determined. The values obtained (42 and 33 m.e./100 gms. for the coarse clay fractions and 53 and 47 m.e./100 gms. for the fine clay fractions) are of the same order as those of most soil clays. A consideration of the selective affinity of clays for various cations suggests that the relative numbers of different ca-

tion present as exchangeable bases on submarine clays are as follows: 53% Na, 34% Mg, 11% Ca, and 2% K.

X-ray and petrographic analyses show that the three common groups of clay minerals present in soils, namely, illite, kaolin, and montmorillonite are also the main constituents of marine clays. Illite is present in all of the samples and is the predominant clay mineral in 23 of them. It is particularly abundant in the deep-sea clays. Kaolin, although less abundant than illite, is also present in all of the samples and predominates in 9 of them, most of which are relatively close to shore. Small amounts of montmorillonite were found in the near shore samples, but, despite the common presence of this mineral in soils, it was not detected in most of the deep-sea sediments. In addition to the clay minerals quartz and feldspar were identified in most of the coarse clay fractions and iron oxide was detected in many of the red clays. Chlorite may also be an important clay constituent of some of the blue and green muds.

Kaolin and montmorillonite were found to have formed on the sea floor by the alteration of the feldspars in granite. Other considerations suggest that illite may also form by the alteration of some primary minerals and, especially, by the alteration of montmorillonite. This latter change involves the absorption into montmorillonite of potassium from sea water. Such a process of illitization might account for (1) the post-depositional increase in the size of clay particles in marine clays, (2) the general absence of montmorillonite in marine clays, (3) the absence of montmorillonite in most shales, and (4) the low potassium to sodium ratio in sea water as compared to that of river water. Illitization is probably an extremely slow process which goes to completion only in areas of slow deposition. The formation of the illite mineral, glauconite, may be a special case of this process.

A study of the samples suggests that the clay mineral distribution on the sea floor is regionally similar to that on land in having a relative abundance of kaolin and iron oxide in tropical regions and of illite and montmorillonite in temperate and polar regions. This suggests that deep sea clays are terrestrially derived.

VITA

Robert Sinclair Dietz was born in Westfield, New Jersey, September 14, 1914. After receiving his elementary and high school education in the public schools of that city, he attended the University of Illinois where he received a B.S. degree in February 1937 and a M.S. degree in Geology in June 1939. He served as teaching assistant in the Department of Geology and Geography of the University of Illinois from February 1939 to February 1940 and was a fellow at that University from September 1940 through June 1941. From September 1937 to June 1938 and from July 1940 to December 1940, he studied in absentia under Dr. F. P. Shepard at the Scripps Institution of Oceanography of the University of California at La Jolla, California. During 1938, he assisted in geological studies of the sea floor off the coast of California by participating in six cruises of the research vessel *E. W. Scripps*. From October through December 1940, he was a member of an expedition on this vessel in the Gulf of California.

From October 1935 to August 1937, he was employed one-quarter time during the school year and full time during the summer as a research assistant in the Coal Division of the Illinois State Geological Survey. During the summer of 1939 and the spring of 1940, he was employed by Ralph E. Grim of the Illinois State Geological Survey in a study of the clay minerals in Recent marine sediments off California.

He has collaborated with F. P. Shepard and U. S. Grant IV in *The Emergence of (Santa) Catalina Island, American Journal of Science,* vol. 237, (1939), p. 651-55 and with F. P. Shepard and R. R. Revelle in *Ocean-Bottom Currents off the California Coast,* Science, vol. 89, (1939), p. 488-98. Unpublished manuscripts include *Phosphorite Deposits on the Sea Floor off Southern California* written in collaboration with K. O. Emery and F. P. Shepard, and *A Gravity Coring Device and the Mechanics of Sediment Coring* with K. O. Emery.

He is a member of Phi Beta Kappa, Sigma Xi, and the Illinois Academy of Science.